WL-TR-95-5042

ARPA

WRIGHT LABORATORY

NOVEL LARGE AREA, HIGH THROUGHPUT, HIGH RESOLUTION, PATTERNING SYSTEM PROGRAM

PROGRAM SUMMARY

Anvik Corporation
250 Clearbrook Road
Elmsford, NY 10523

Prepared by:
Texas Instruments Incorporated
Defense Systems & Electronics
13532 N. Central Expressway
Dallas, Texas 75265

August 1995

SUMMARY
September 13, 1995 - June 23, 1995

19960304 092

Approved for Public Release; Distribution is Unlimited.

Solid State Electronics Directorate
Wright Laboratory
Air Force Materiel Command (AFMC)
Wright-Patterson AFB, OH 45433-7405

NOTICE

WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY GOVERNMENT-RELATED PROCUREMENT, THE UNITED STATES GOVERNMENT INCURS NO RESPONSIBILITY OR ANY OBLIGATION WHATSOEVER. THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA, IS NOT TO BE REGARDED BY IMPLICATION, OR OTHERWISE IN ANY MANNER CONSTRUED, AS LICENSING THE HOLDER, OR ANY OTHER PERSON OR CORPORATION; OR AS CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

THIS TECHNICAL REPORT HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION.

James G. Grote

JAMES G. GROTE, Project Engineer
Electro-Optics Branch
Device Technology Division

Charles H Stevens

CHARLES H. STEVENS, Chief
Electro-Optics Branch
Device Technology Division

Gary L McCoy

GARY L. McCOY, Chief
Device Technology Division
S.S.Electronics Directorate

IF YOUR ADDRESS HAS CHANGED, IF YOU WISH TO BE REMOVED FROM OUR MAILING LIST, OR IF THE ADDRESSEE IS NO LONGER EMPLOYED BY YOUR ORGANIZATION, PLEASE NOTIFY WL/ELDO, WRIGHT-PATTERSON AFB OH 45433-7323 TO HELP MAINTAIN A CURRENT MAILING LIST.

COPIES OF THIS REPORT SHOULD NOT BE RETURNED UNLESS RETURN IS REQUIRED BY SECURITY CONSIDERATIONS, CONTRACTUAL OBLIGATIONS, OR NOTICE ON A SPECIFIC DOCUMENT.

REPORT DOCUMENTATION PAGE	Form Approved QMB No. 0704-0188

1. Agency Use Only (Leave Blank)	2. Report Date 22 Aug 1995	3. Report Type and Dates Covered Final - 13 Sept 95 - 23 Jun 95

4. Title and Subtitle
Novel Large Area,High Throughput,High Resolution Patterning Sys. Program;Program Summary

5. Funding Numbers
C: F33615-93-C-1331
PE: 62301E & 63739E
PR: 9316
TA: 02
WU: 01

6. Author(s)
Dr. Kanti Jain and Greg Lievan

7. Performing Organization Name(s) and Address(es)
Texas Instruments Inc
P.O. Box 655012
Dallas, TX 75265

Anvik Corporation
250 Clearbrook
Elmsford, NY 10523

8. Performing Organization Report Number

9. Sponsoring/Monitoring Agency Name(s) and Address(es)
Solid State Electronics Directorate
Wright Laboratory
Materiel Command (AFMC)
Wright-Patterson AFB, OH 45433-7331

10. Sponsoring/Monitoring Agency
WL-TR-95-5042

11. Supplementary Notes
This effort was funded by ARPA/ESTO, 3701 N. Fairfax Drive, Arlington, VA 22203-1714.
The effort is Phase IB of the ARPA ASEM Program.

12a. Distribution/Availability Statement
Approved for Public Release; Distribution is Unlimited.

12b. Distribution Code

13. Abstract (Maximum 200 words)
The objective of this phase ia program is to demonstrate a concept for a high resolution ultra violet (UV) based optical patterning system technology for production of both electronic and electro-optical multichip modules (MCMs) and flat panel displays.
The tasks identify patterning system requirements, investigate different optical and mechanical design options, perform comparativ analysis of design options, procure hardware, demonstrate large area patterning, procure masks, conduct via etching experiments, perform cost study, and determine limits of the system. A proof-of-concept patterning system was assembled. It was used to demonstrate large-area seamless patterning using multiple, partially overlapping scans. For patterning resists, the system demonstrated good resolution down to 3 µm . For ablation of polyimide, vias showed excellent resolution down to 10 µm. Ablation of 6 µm wide lines and spaces was demonstrated.

14. Subject Terms
Processing, Precision Fabrication, Laser Applications, Excimer Laser Lithography

15. Number of Pages
7

16. Price Code

17. Security Classification of Report	18. Security Classification of this Page	19. Security Classification of Abstract	20. Limitation of Abstract
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

MSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Proposed by ANSI STD 239-18
298-102

Table of Contents

1.	INTRODUCTION	1
2.	SUMMARY AND RESULTS	2
3.	CONCLUSION	4

1. Introduction

In the manufacturing of multichip modules (MCM's) and other high-performance electronic packages, patterning of the various resist, dielectric, and metal layers constitutes the most important segment of the total fabrication process. Currently used patterning and via-drilling methods suffer from several inherent disadvantages. Anvik's novel large-area patterning technology offers a breakthrough that overcomes the limitations of existing methods and achieves the combined capabilities of large field size, high resolution, and high throughput. The goal of this ARPA-sponsored Texas Instruments-Anvik program is to develop Anvik's technology into advanced manufacturing equipment that will significantly improve the cost-effectiveness of high-volume manufacturing of MCM's, flat-panel displays, and printed circuit boards.

The key objectives of the Phase 1A effort were to carry out risk reduction tasks and establish technical feasibility by designing, building, and demonstrating a proof-of-concept patterning and via-drilling system prototype. The goals in Phase 1B were to conduct detailed experiments to demonstrate the full advantages of the new technology. This work is in preparation for a possible follow-on effort, which will be devoted to designing, building, and testing a production-worthy hardware prototype of the proposed system.

2. Summary and Results

This Summary Report provides an overview of the development and characterization of a proof-of-concept large-area patterning and via-drilling system prototype. In Phase 1A, an investigation of patterning requirements for different applications was conducted, and an analysis of different design configurations to meet those requirements was given. Based on this analysis, a proof-of-concept prototype was designed and assembled. We successfully demonstrated our seamless scanning technique for exposure of photoresist as well as photoablation of interlayer dielectric materials. In Phase 1B, the system hardware, control software, and alignment techniques were upgraded to give diffraction-limited resolution of 3 μm in photoresist over a full 5 x 5 inch substrate with Anvik's seamless scanning technique. Photoablation of 10 μm vias and 6 μm lines and spaces was demonstrated in polyimide. Detailed resist exposure experiments were conducted to study different resists and optimize the processing parameters. Detailed experiments on photoablation were also conducted using different dielectric materials; this work required the use and characterization of multilayer dielectric masks.

The design concept chosen is based on the use of a single, planar scanning stage on which both the mask and the substrate are mounted. This configuration is shown in Fig. 1. The mask is illuminated with a hexagonal illumination pattern produced by an illumination system situated below the mask. The illuminated region of the mask is imaged with a projection lens and several beam-folding mirrors to produce an image of the illuminated mask region on the substrate. Note that the optical axis through the projection lens is in a horizontal plane, and a reversing assembly is used in the imaging path to undo the image reversal caused by the lens. This produces an image on the substrate in the same orientation as the mask pattern, which enables the use of a single stage. It is readily seen that this design approach is highly modular, in the sense that each of the main subsystems, namely, the projection system, the illumination system, and the stage system, can be separately optimized and an overall system configuration most suitable for any given application can be assembled.

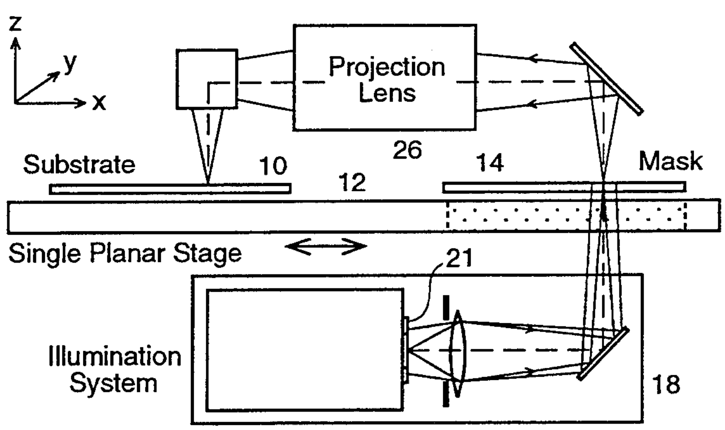

Fig. 1. Anvik's large-area, high-throughput lithography and via-drilling system, showing a board and a mask held rigidly on a single planar stage, an illumination system, and a projection lens.

In Figs. 2 and 3, we show some of the excellent patterning results achieved using the Anvik lithography tool. We show results from both patterning of photoresists and via-drilling in polyimide. Figure 2 shows good 3 μm imagery in 1.1 μm thick UCB-JSR TI 080 photoresist. This resolution was achieved across the entire substrate with no seams as a result of the scanning hexagonal illumination. In Fig. 3 we show the results of photo-etching in 8.3 μm thick Pyralin PI 2611D polyimide by excimer ablation, showing patterning of 100, 50, and 10 μm vias and a checkerboard pattern of 10 μm square vias. For both resist exposure and via-drilling, we demonstrated a throughput advantage of 5X over current lithography tools.

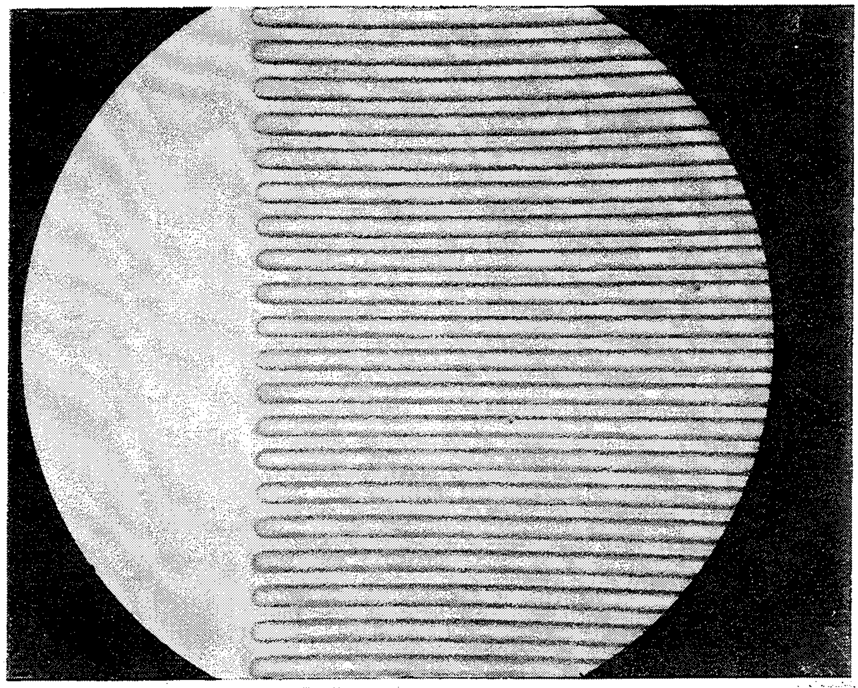

Fig. 2. Results obtained with the Anvik prototype system showing resolution of 3 μm lines and spaces patterned in JSR TI 080 resist.

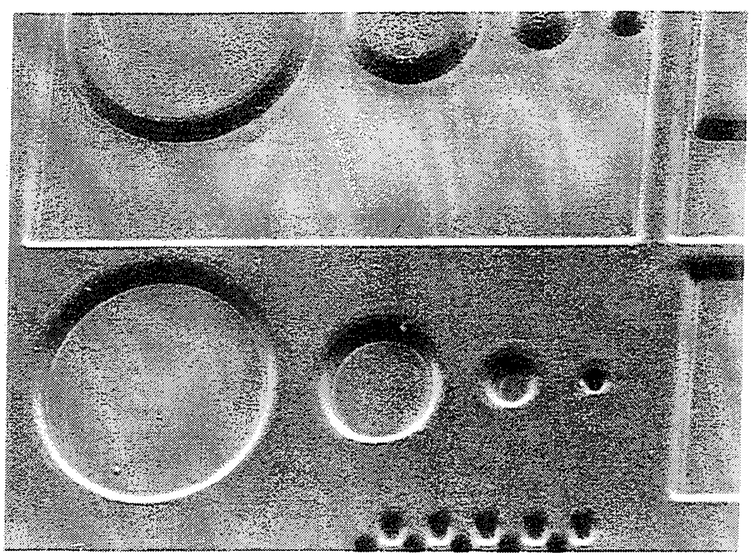

Fig. 3. Scanning electron micrograph showing patterns ablated in Dupont Pyralin PI 2611D polyimide. The bottom row shows 100, 50, 20, and 10 μm round vias and a checkerboard pattern of 10 μm square vias. The top row shows pillars of the same dimensions.

3. Conclusion

In this Phase 1 program, we have successfully demonstrated the feasibility of Anvik's patterning technology. We have fully assembled a proof-of-concept patterning system and demonstrated large-area seamless patterning using multiple, partially overlapping scans. We have also carried out seamless, scan-and-repeat exposure of polyimide to demonstrate large-area batch drilling of vias. For patterning in resist, we have demonstrated good resolution of 3 micron lines and spaces, and for via ablation in polyimide, we have drilled 10 μm vias and 6 μm lines and spaces with excellent resolution.